NOTES ON FISHES IN THE INDIAN MUSEUM.

III. On Fishes belonging to the Family Cobitidae from high altitudes in Central Asia.

By Sunder Lal Hora, *M.Sc., Assistant Superintendent, Zoological Survey of India.*

The Cobitid fishes[1] from the high altitudes of Central Asia are generally characterized by the absence of a suborbital spine, by the elongate form of their body, especially of the caudal peduncle, and by the total absence of any scales. The belly is generally rounded and not depressed. The Indian Museum possesses a large number of specimens of this family from Tibet, Northern Kashmir, Western Turkestan and Seistan. When dealing with the fish of Seistan it was pointed out by Annandale and myself[2] that among those specimens which have been referred by several ichthyologists to *Nemachilus stoliczkae* Steind. there were several forms capable of specific separation. In this note an attempt is made to elucidate these points and to discuss the specific validity of the various species represented in our collection.

Here are also incorporated the results of an examination of the loaches recently collected in Kashmir by officers of the Zoological Survey of India.

At the end I have added a short note on the sexual dimorphism exhibited by some of these species.

The Central Asiatic forms belonging to the family Cobitidae dealt with in this note may be grouped into three distinct genera, which can be distinguished in the following manner:—

A.	Two bladders; one lying free in abdominal cavity and second divided into two lateral chambers enclosed in bone	*Diplophysa.*
B.	One bladder, consisting of two lateral chambers enclosed in bone.	
	I. Soft dorsal fin between spiny dorsal and caudal fins present	*Adiposia.*
	II. Soft dorsal fin absent	*Nemachilus.*

Genus Diplophysa Kessler.

1874. *Diplophysa*, Kessler, *Bull. Soc. Sci. Moscou* XI, pp. 1-63.
1888. *Lefua*, Herzenstein, *Wiss. Res. Prezewalski Central Asia. Reis., Zool.* III (2), p. 91,

Unfortunately the paper in which Kessler proposed the generic

[1] A large number of specimens of the Cobitid genus *Botia*, which possesses spines below the eye, have recently been collected in Kashmir. The genus extends to China as well, but I have not dealt with it here.

[2] Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 179 (1920).

name *Diplophysa*, is not available in Calcutta, so I take from Day [1] the characters on which this genus was erected. The genus *Diplophysa* comprises those fishes in which the body is greatly elongated and strongly compressed posteriorly; the eyes are surrounded with a fold of skin forming a lid; the lips are fleshy, the upper more or less denticulated, the inferior bilobed and more or less papillated and the air-vessel is divided into two parts, the anterior enclosed in a bony capsule and the posterior elongated and free in the abdominal cavity. I agree with Day (*op. cit.*) that the first three characters do not possess any generic value, but the last feature, that of the air-vessel, is quite sufficient to distinguish the genus *Diplophysa* from *Nemachilus*, to which it is closely allied. Day did not dispute the validity of the last character but suggested a re-examination of the Western Turkestan specimens and remarked that, "it would be very remarkable were the *Nemacheili* found in Europe, in fact throughout Asia, even in the Oxus, to have their air-vessel enclosed in bone, whereas in the river Ili going to Lake Balkash, and the river Urdjar falling into Lake Ala (Ala-Kul), to have the same organ partially free in the abdomen, as is seen in the genus *Botia*." Day did not think himself justified in recognising *Diplophysa* as a distinct genus from *Nemachilus* even on the character of the air-bladder, which is so remarkable.

Kessler [2] in 1879, when dealing with the Central Asiatic fishes, upheld his genus *Diplophysa* and described two new species under this generic designation. In reviewing Day's criticism of the genus he pointed out that in all probability Dr. Stoliczka's collection was made in the area south west of the Tarim river-system, while Przewalski's collection, which contained several representatives of the genus, was made much further to the east. Moreover he considered the air-bladder to be as important for taxonomic purposes as the pharyngeal teeth, on which the two families Cobitidae and Cyprinidae are distinguished.

Herzenstein [3] in his valuable monograph of Central Asiatic fishes agreed with Day and considered *Diplophysa* synonymous with *Nemachilus*. But at the same time he instituted a new genus *Lefua* to accommodate *Diplophysa costata* Kessler and *Octonema pleskei* Herz. He characterized the genus *Lefua* as follows:— "Caput valde depressum. Os fere terminale. Spina suborbitalis nulla. Nares anteriores cirro sat longo instructae. Cirri rostrales 4, supra-maxillares 2. Vesicae natatoriae pars posterior in cavitate abdominali libere suspensa." No notice seems to have been taken of this genus till 1907 when Berg [4] recognised it and considered the Japanese genus *Elixis* Jordan and Fowler [5] as a synonym of

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[1] Day, *Proc. Zool. Soc. London*, p. 793 (1876); *Sci. Res. 2nd. Yarkand Mission, Ichthyol.*, p. 12 (1878).

[2] Kessler, *Bull. Acad. Sci. St. Pétersbourg* XXV, p. 302 (1879).

[3] Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 1 (1888).

[4] Berg, *Proc. U.S. Nat. Mus.* XXXII, p. 437 (1907).

[5] Jordan and Fowler, *Proc U.S. Nat. Mus.* XXVI, p. 768 (1903).

Lefua, the definition of which he modified as follows:—"Cirri 8, four rostral, two maxillary and two at the anterior nostrils. Scales present. No erectile spine below the eye. Dorsal fin about over the ventral, with few rays; caudal rounded. Air-bladder with a posterior part free in the abdominal cavity." The genus *Elixis* was established to comprise those species of *Nemachilus* which possessed a pair of nasal barbels in addition to six others that surround the mouth. In *E. nikkonis*, the genotype of the genus, and in *E. coreanus* subsequently described by Jordan and Starks [1] no mention is made as to the nature of the air-bladder in them. I have examined some Indian species of the genus *Nemachilus*, such as *N. evezardi* Day [2] which possess a pair of well-developed nasal barbels but have not found in them a free bladder in the abdominal cavity. It is quite probable that the Japanese species with eight barbels may not possess a free bladder as is said to be present in the Chinese species with eight barbels assigned to the genus *Lefua* by Herzenstein. I am led, therefore, to believe that Berg united the two genera merely on the consideration of the nasal barbels and paid little attention to the character of the air-bladder. He, moreover, considered *Nemachilus dixoni* Fowler,[3] *Elixis coreanus* Jordan and Starks and the two forms included by Herzenstein under his genus *Lefua* as representing only one species, having examined a large number of specimens from widely different localities in China and Korea. I doubt the validity of this statement and suggest a re-examination of these specimens. There seems to me nothing at present in the definition of *Lefua* and *Elixis*, except the presence of nasal barbels, which could justify their separation from *Diplophysa* and *Nemachilus* respectively, but Annandale and I (*op. cit.*, p. 185) have already pointed out that we do not consider it a character of generic value. I conclude, therefore, that *Lefua* is a synonym of *Diplophysa* and *Elixis* of *Nemachilus*.

Quite recently Weber and Beaufort [4] have recognised the genus *Elixis* and have referred *Nemachilus obesus* Vaill,[5] to it only on the character of the nasal barbels.

In a recent contribution to the ichthyology of Central Asia, Zugmayer [6] has recognised the genus *Diplophysa* as distinct from *Nemachilus*, though closely allied to it. The chief distinction between the two genera lies in the fact that according to Zugmayer a part of the air-vessel lies free in the abdominal cavity in *Diplophysa*, whereas in *Nemachilus* it is wholly enclosed in a bony capsule. Having examined the air-bladder in *Diplophysa papilloso-labiata* Kessler, Zugmayer states that the two parts are distinct from each other.

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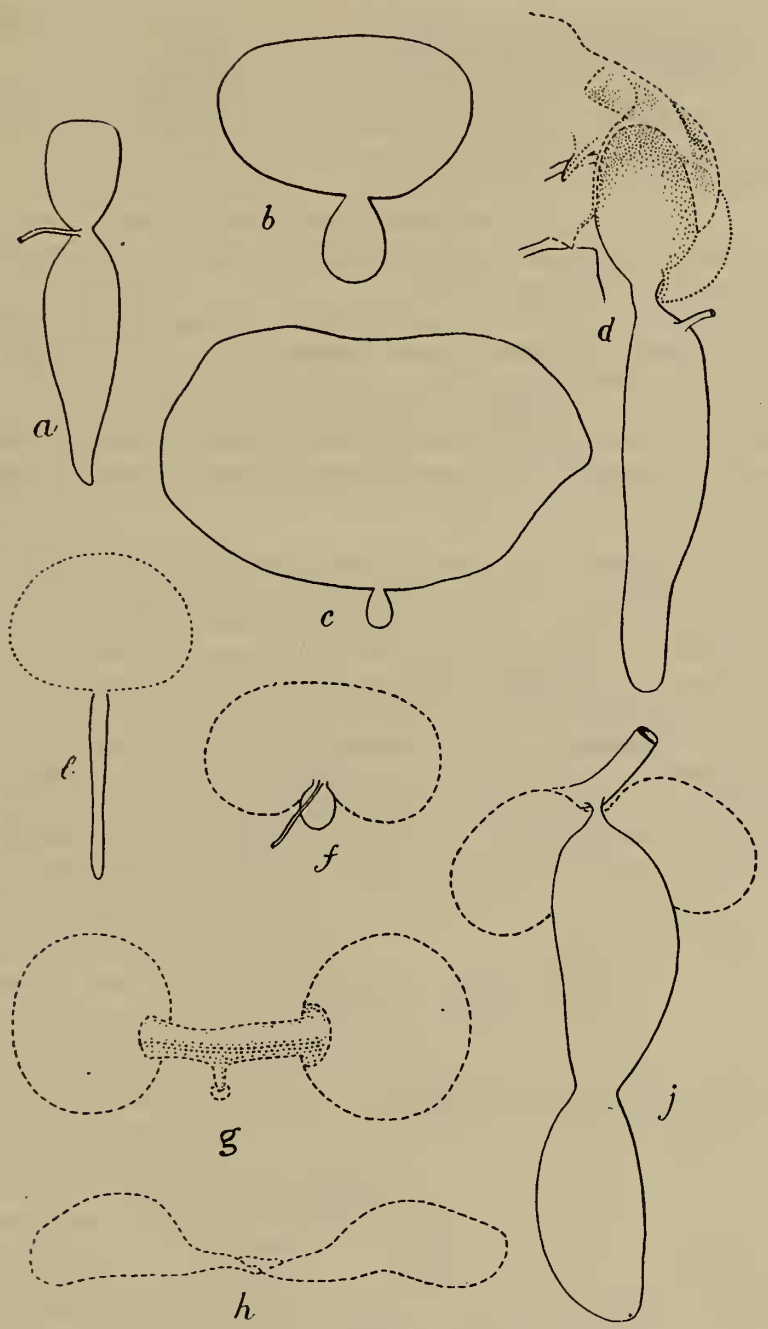
[1] Jordan and Starks, *Proc. U.S. Nat. Mus.* XXVIII, p. 201, fig. 7 (1905).
[2] Day, *Fish. India* II, p. 613, pl. cliii, fig. 11 (1878).
[3] Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, p. 181 (1899, 1900).
[4] *Weber and Beaufort, Fishes Indo-Austral. Archipel.* III, p. 35, fig. 16 (1916).
[5] Vaillant, *Notes Leyden Mus.* XXIV, p. 134 (1902).
[6] Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 294 (1910).

I have myself examined specimens of the same species in our collection and agree with Zugmayer's statement. Both Kessler and Zugmayer believe that there is only one bladder in *Diplophysa* and that the anterior part is enclosed in bone while the posterior lies free in the abdominal cavity. Zugmayer found the two bladders to be quite distinct from each other but regarded them as parts of the same bladder. On examining the bladder in young specimens of a new species from Eastern Tibet (Rham-tso) I find that the two bladders are totally distinct from each other and that they are not the two parts of a single structure. The posterior bladder, that lies free in the abdominal cavity, is connected with the oesophagus by a short pneumatic duct given off from its anterior end. This duct is only distinct in young specimens and atrophies in the adult. In order to understand the true significance of the posterior bladder and its relation to the anterior, it is necessary to examine the various types of bladder commonly met with among the different genera of Cyprinoidea.

The swim-bladder of a typical Cyprinid fish such as *Labeo rohita* is large and lies free in the abdominal cavity. It is constricted in the middle to form an anterior and a posterior chamber (fig. 1*a*). The pneumatic duct from the oesophagus opens into the constricted region. In those genera that live in rapid running waters the bladder undergoes considerable degeneration; this consists firstly in the gradual reduction of the two chambers and the ultimate disappearance of the posterior, and secondly, in the thickening of their walls. In extreme cases the bladder becomes completely enclosed in a bony capsule derived from the transverse processes of the adjacent vertebrae.

In the genus *Psilorhynchus* the posterior chamber is greatly reduced and the anterior is covered by a thick fibrous coat (figs. 1*b*, 1*c*). In *Nemachilus vittatus* from the Kashmir Valley the anterior chamber is laterally flattened and covered by a bony capsule while the posterior chamber is small and thick walled (fig. 1*f*). The pneumatic duct still opens into the constricted region between the two chambers. In other species of this genus the anterior part is divided into two lateral chambers which are enclosed in a bony capsule and all remains of the posterior chamber are wanting. In *Adiposia rhadinaea* there is still a short bulb-like structure representing the posterior chamber (fig. 1*g*) otherwise it is very similar to that found in most species of *Nemachilus*. In extreme cases such as *Balitora brucei* the two lateral halves of the anterior chamber are much reduced and are somewhat separated from each other (fig. 1*h*).

Among the members of the genus *Diplophysa* the anterior bladder (fig. 1*j*), which is enclosed in a bony capsule, is in all probability similar to that found in the genus *Nemachilus* and, thus, it may represent the primary or the true original bladder of the fish. The posterior bladder, that lies free in the abdominal cavity, is a secondary structure and in its origin and position is



TEXT-FIG. 1.—Types of air-bladder found in Cyprinoid fishes.

a, Labeo rohita. *b, c, Psilorhynchus balitora.*
d, Botia hymenophysa. *e, Botia almorhae.*
f, Nemachilus vittatus. *g, Adiposia rhadinaea.*
h, Balitora brucei. *j, Diplophysa stewarti.*

The dotted line in the figure indicates that the portion thus outlined is enclosed in bone.

quite different from the normal Cyprinoid bladder. The following are the chief points of difference:—

(i) There is a short pneumatic duct from the anterior end of the bladder to the oesophagus, while in the normal Cyprinoid type the pneumatic duct is long and opens into the middle of the bladder in the constricted region.

(ii) The bladder may or may not be constricted in the middle.

(iii) The pneumatic duct is present only in young specimens, while it is lost in the adult.

In the genus *Botia*, the structure of the air-bladder differs considerably. Though in many respects of a typical Cyprinoid form, the anterior chamber is partially (fig. 1*d*) or wholly (fig. 1*e*) enclosed in a bony capsule formed by the transverse processes of the neighbouring vertebrae. On comparing drawings *d* and *j* in figure 1, it will be seen that Day was in error in suggesting that the bladder of *Diplophysa* would have to be similar in structure to that in *Botia*.

The reduction of the swim-bladder in fishes that live in rapid-running waters is in all probability due to the fact that they live on the bottom and do not require to make vertical movements. The enclosure of the bladder in a bony capsule presumably has some special biological significance, but of this nothing is yet known. Zugmayer believed that the free bladder in *Diplophysa* is to be explained by the assumption that the members of the genus have not yet acquired a true ground habit and that consequently the posterior half has not yet been affected. This, however, does not appear to be a correct interpretation of the fact as there are two distinct air-bladders in *Diplophysa*, the one enclosed in a bony capsule being possibly the original Cyprinoid bladder, while the other that lies free in the abdominal cavity is either a secondary acquisition or, as Dr. Annandale suggests to me, represents the modified posterior chamber of the normal Cyprinoid bladder. In the latter case the anterior chamber has become enclosed in bone, as in *Nemachilus vittatus*, and the posterior chamber was nipped off, retaining its connection with the oesophagus through the primary pneumatic duct. The members of the genus *Diplophysa* have in all probability come to live secondarily in the deep muddy waters of the lake-basins of Central Asia in which situation they require a hydrostatic organ for vertical movements; I believe that they have originated from forms like *Nemachilus* in which the air-bladder is reduced and enclosed in a bony capsule. When the primary air-bladder became enclosed in bone it probably could not again be modified for the performance of a hydrostatic function to suit the new environment. I thus believe that *Diplophysa* is a more specialized genus than *Nemachilus*, whereas Zugmayer regards it as more primitive. Of the species of *Diplophysa* at present known, all described by Kessler, the following have been recorded either from lakes or from deep muddy waters at great altitudes in Central Asia:—

Diplophysa strauchii,		Ili river flowing into Lake Balkash.
,,	*labiatus*,	Urdjar river flowing into Ala-kul.
,,	*intermedius*,	Lake Dalai-nor.
,,	*nasalis*,	,,
,,	*costata*,	,,
,,	*dalaicus*,	,,
,,	*kungessana*,	Kinges River.
,,	*papilloso-labiata*,	Juldus.
,,	*microphthalmus*,	Chami.

Of the nine species enumerated above the first two are from Eastern Turkestan, the next four from Lake Dalai-nor, which is situated in the lake basin of Mongolia, and the remaining three from the Tarim river-system which ultimately drains into lake Lob-nor. It is significant that all the Cobitid fishes known from Lake Dalai-nor belong to the genus *Diplophysa*. A new species of this genus described here was obtained by Capt. Kennedy and Capt. Stewart in a small stream flowing into Rham-tso, a lake of considerable dimensions at an altitude of 14,700 ft. in Eastern Tibet.

It will thus be seen that the genus is known from Eastern Turkestan and Mongolia on the one hand and from Rham-tso in Eastern Tibet on the other. This apparently discontinuous distribution may be accounted for by the fact that very little is at present known of the ichthyology of the intermediate region.

There is yet another possibility which may explain the distribution of this genus. It is possible that the genus is polyphyletic in origin, because the character of the bladder on which it is solely based, may have originated on more than one occasion in response to life in deep waters which necessitated some hydrostatic mechanism.

The genus *Diplophysa* is represented by two species in the collection of the Indian Museum, one of which is new to science.

Diplophysa papilloso-labiata Kessler.

1878. *Diplophysa papilloso-labiata*, Kessler, *Bull. Acad. St. Pétersbourg* XXV, p. 299..
1878. *Diplophysa papilloso-labiata*, Kessler, *Mél. biol.* X, p. 257.
1888. *Nemachilus strauchii* var. *papilloso-labiatus*, Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 50, pl. vi, fig. 5.
1910. *Diplophysa (Nemachilus) strauchii papilloso-labiata*, Zugmayer, *Zool. Zahrb. Syst.* XXIX, p. 297.

This is the only species of the genus *Diplophysa* collected by Dr. Stoliczka. There are seven specimens in our collection and they are labelled as having come from Yarkand, probably from the Yarkand river which forms a part of the Tarim river-system. Of the seven specimens four are males and the rest females. The species exhibits a well-marked sexual dimorphism.

The free air-bladder is not constricted in the middle and lies almost in the middle of the abdominal cavity. In my dissections I have not been able to find any pneumatic duct.

The eggs of this species are very small and almost fill the whole of the abdominal cavity.

Diplophysa papilloso-labiata is known only from the Tarim river-system (Eastern Turkestan). The longest specimen in our collection is 105 mm. in length without including the length of the caudal fin.

Diplophysa stewarti, sp. nov.

(Text-figs. 2*c*, 2*d*.)

1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.* II, p. 341.

1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70.

1920. *Nemachilus lhasae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 179.

This species is represented in our collection by several young and half-grown specimens. It closely resembles *Nemachilus lhasae* Regan with which Annandale and myself [1] confused it when dealing with the fish of Seistan. Both Lloyd and Stewart referred these specimens along with *Nemachilus lhasae* to *N. stoliczkae*. *Diplophysa stewarti* is, however, readily distinguished by the presence of a second air-bladder and also by the nature of its skin, which is tuberculate all over.

The dorsal profile is highest near the nape, in front of which it slopes considerably to the tip of the snout. The body is thickest anteriorly and gradually and regularly slopes to the base of the caudal fin. The head is round, narrow and pointed; its length is contained 4·2 times in the length of the fish without the caudal fin. The body is deepest at its commencement and the greatest depth of the body is contained 1·6 times in the length of the head. The eyes are placed in the middle of the head and are scarcely visible from below; the diameter is contained 3·4 to 3·7 times in the length of the head. There are six barbels, 4 rostral and 2 maxillary. The maxillary barbels are the longest; they are slightly longer than the diameter of the eye. The upper lip is fringed and the lower is interrupted in the middle and is strongly papillated. The lateral line is complete; anteriorly it is continued as a series of open pores below the eyes. There are a few open pores on the dorsal surface of the head near its posterior border extending downwards on each side to join the lateral line. The dorsal fin commences considerably in advance of the ventrals and its origin is equidistant from the tip of the snout and the base of the caudal fin. It is higher than the depth of the body immediately below it. The ventrals extend beyond the anal opening and almost reach the base of the anal fin. The caudal peduncle is long and narrow; its least height is contained 6·1 to 6·6 times in its length. The caudal fin is deeply concave with the upper lobe considerably longer than the lower.

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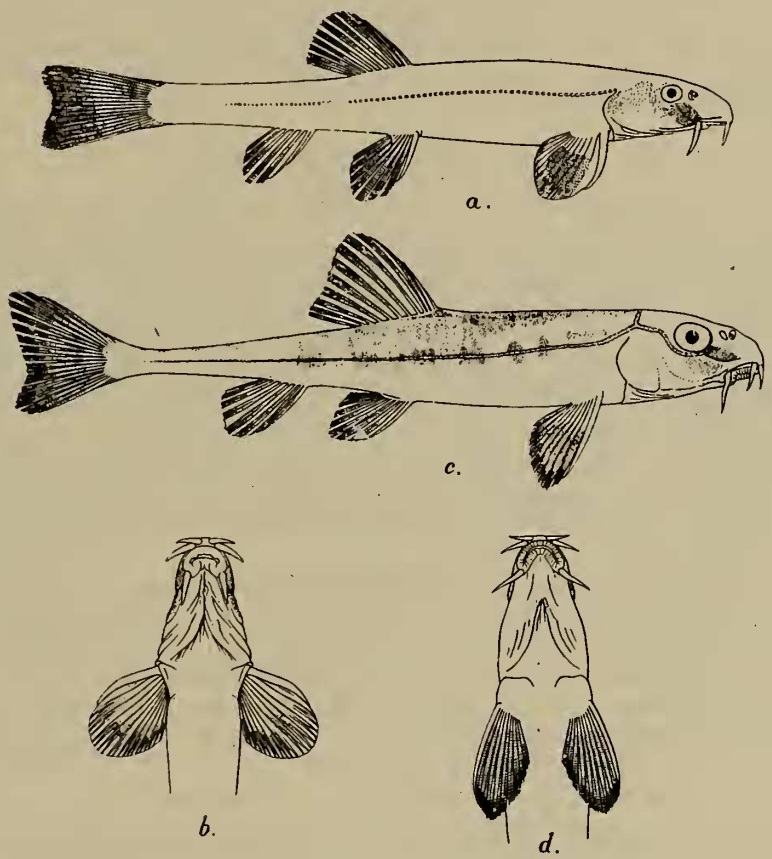
[1] Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 179 (1920).

This species exhibits sexual dimorphism and the males can readily be distinguished by a tuberculate pad below the eye.

The secondary bladder is large and constricted in the middle. It differs from the normal Cyprinoid type in the fact that the pneumatic duct here opens at the anterior end instead of in the constricted region.



Text-fig. 2.—Cobitid fishes from Eastern Tibet.

a. Lateral view of *Nemachilus tibetanus* Regan.
b. Under surface of head and chest of same.
c. Lateral view of *Diplophysa stewarti*, sp. nov.
d. Under surface of head and chest of same.

The colour in spirit is characteristic of the species. There are short black bars along the lateral line and on the back. The belly and under surface of the head and also the general colour of the body is pale olivaceous. The dorsal and the caudal fins are marked with black.

Type-specimen.—F. 2894/1, *Zoological Survey of India* (*Ind. Mus.*).

Locality :—The specimens were collected by Capt. R. S. Kennedy, I.M.S., and Capt. F. H. Stewart, I.M.S., in a small

stream flowing into Rham-tso (Eastern Tibet). There are two young specimens from Se-Chen in Tibet, which I also refer to this species.

Genus **Adiposia**, Annandale & Hora.

1920. *Adiposia*, Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 182.

The genus was recently proposed by Annandale and myself for two species of Cobitid fishes from Seistan with a long soft dorsal fin between the bases of the dorsal and the caudal fins. We also referred a species from Turkestan, *Adiposia longicauda* (Kessler),[1] to this new genus.

Genus **Nemachilus** v. Hass.

The thirteen species of the genus *Nemachilus* from Central Asia in the collection differ from the numerous forms known from the Indian Empire in their large size and almost subcylindrical form. None of them, moreover, possesses the vertical bands of pigment which characterize those from lower altitudes.

The following is an artificial key to the Central Asiatic species of *Nemachilus* in the collection of the Indian Museum :—

I. Ventrals terminating a considerable distance in front of anal opening.
  A. Eyes wholly in anterior half of head, dorsal commencing in advance of ventrals. ... ... *N. yarkandensis.*
  B. Eyes in middle of head; ventrals commencing in advance of dorsal ... ... *N. gracilis.*

II. Ventrals just reaching or extending beyond anal opening.
  A. Anterior origin of dorsal almost equidistant between tip of snout and base of caudal.
    1. Lateral line incomplete, ending shortly after its commencement ... ... *N. vittatus.*
    2. Lateral line complete or becoming somewhat obscure behind anal fin.
      a. Eye almost in middle of head.
        i. Pectorals as long as head ... ... *N. yasinensis* ♂.
        ii. Pectorals shorter than head.
          α. Least height of caudal peduncle almost equal to diameter of eye ... ... *N. lhasae.*
          β. Least height of caudal peduncle considerably greater than diameter of eye. ... ... *N. kashmirensis.*
      b. Snout longer than postorbital part of head ... *N. tenuis.*
  B. Anterior origin of dorsal not equidistant between tip of snout and base of caudal.
    1. Anterior origin of dorsal nearer tip of snout than base of caudal ... ... *N. ladacensis.*
    2. Anterior origin of dorsal nearer base of caudal than tip of snout.
      a. Eye in middle of head.
        i. Ventrals distinctly extending beyond anal opening.
          α. Least height of caudal peduncle 4 times in its length, lower lip almost continuous ... ... *N. stoliczkae.*
          β. Least height of caudal peduncle 5 times in its length, lower lip widely interrupted ... *N. tenuicauda.*
        ii. Ventrals just reaching anal opening ... ... *N. marmoratus.*

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[1] Kessler "Pisces" in Fedtschenko's "*Reise in Turkestan*," p. 38, pl. vi, figs. 22, 23 (1874).

b. Eye not in middle of head.
  i. Snout shorter than postorbital part of head.
    a. Anal fin separated from caudal by a distance almost equal to its own length ... ... *N. microps.*
    β. Anal fin separated from caudal by a distance considerably less than its own length ... *N. yasinensis* ♀.
  ii. Snout longer than postorbital part of head. ... *N. tibetanus.*

Nemachilus yarkandensis Day.

1876. *Nemachilus yarkandensis*, Day, *Proc. Zool. Soc. London*, p. 79.
1878. *Nemachilus yarkandensis*, Day, *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 14, pl. v, fig. 3.
1889. *Nemachilus yarkandensis*, Herzenstein (in part), *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 74.
1910. *Nemachilus yarkandensis*, Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 295.

The Indian Museum possesses a large number of specimens of this species from Yarkand, Pas Robat, Yankihissar and Kashgar. Besides these there is one specimen about 132 mm. in length labelled as having come from Kashmir which I am convinced also belongs to this species. So far *N. yarkandensis* has been recorded only from the Tarim River system and its extension into Kashmir is very doubtful and requires confirmation. My specimens correspond in every detail to the typical form. The various varieties described and figured by Herzenstein are not represented in our collection ; probably they are all far Eastern or Chinese forms.

Nemachilus tarimensis Kessler[1] has been considered to be synonymous with *N. yarkandensis* by Herzenstein, who figures Kessler's original specimen of *N. tarimensis* as *N. yarkandensis* (*s. st.*). After a careful comparison I am lead to believe that the two species are different and that *N. tarimensis* as figured by Herzenstein differs from *N. yarkandensis* in the following points:—

N. tarimensis.	*N. yarkandensis.*
The commencement of the dorsal fin is almost equidistant from the tip of the snout and the base of the caudal fin.	The commencement of the dorsal fin is distinctly nearer to the base of the caudal fin than to the tip of the snout.
The eyes are large and are not situated entirely in the anterior half of the head.	The eyes are small and are situated in the anterior half of the head.

As regards the three varieties of this species, it is difficult to discuss their true relationships without examining Herzenstein's specimens. *N. yarkandensis longibarbus* differs from the typical form in the commencement of the dorsal fin, which is situated in the middle of the body, the longer barbels and the curve of its dorsal profile. Probably it represents a new species. The other two varieties, *brevibarbus* and *macropterus* somewhat resemble our specimens.

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[1] Kessler, *Bull. Acad. St. Petérsbourg* XXV, p. 300 (1878).

Nemachilus gracilis Day.

1876. *Nemachilus gracilis*, Day, *Proc. Zool. Soc. London*, p. 798.
1878. *Nemachilus gracilis*, Day, *Sci. Res. 2nd Yarkand Mission. Ichthyol.*, p. 16, pl. iv. fig. 5.
1878. *Nemachilus gracilis*, Day, *Fish. India* II, p. 621.
1889. *Nemachilus gracilis*, Day, *Faun. Brit. Ind. Fish.* I, p. 237.
1898. *Nemachilus stoliczkae*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 38.

This species is readily distinguished by the nature of its lower lip which is widely interrupted in the middle and is thrown into a longitudinal fold on either side. I have examined Day's type-specimen "from Basgo, on the head waters of Indus."

I also refer to this species a specimen from Lukong River and several others from the affluents of the Yasin River near Darkot. The latter were collected by Col. Alcock. The waters of both these streams flow directly or indirectly into the Indus River. These specimens were previously recorded as *N. stoliczkae*.

Several young, half-grown and adult specimens have recently been collected in the Kashmir Valley. The specimens were obtained from a lake about four miles from Sonmarg. The species exhibits marked sexual dimorphism. The eggs are minute.

The adult individuals possess 6 to 7 broad black bands across the back. In young specimens there is a series of black dots along the lateral line and the dorsal surface is mottled with black and brown.

Nemachilus vittatus (Heckel).

1838. *Cobitis vittata*, Heckel, *Fische Kaschm.*, p. 80, pl. xii, figs. 3 and 4.
1844. *Cobitis vittata*, Heckel, in Hügel's *Kaschmir* IV, p. 382, fig.

Günther [1] combined Heckel's two species of this genus from Kashmir and adopted for them the specific name *marmoratus*. Day [2] followed Günther and recognised only one form from the Kashmir lakes. Zugmayer [3] perhaps doubted Günther's identification and in recording *Nemachilus marmoratus* from "Wular Lake" gave Günther as the author of the species. On examining the old collection of the Indian Museum, I find that out of 17 specimens from the Kashmir lakes, 16 belong to *N. vittatus* and one to another species. *N. vittatus* can be readily recognised by the nature of its lateral line which ends shortly after its commencement.

I have not included references by Günther, Day and Zugmayer under the title of this species as it is impossible to be sure of the identity of the species they recorded. They do not make any

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[1] Günther, *Cat. Brit. Mus. Fish.* VII, p. 356 (1868).
[2] Day, *Proc. Zool. Soc. London*, p. 798 (1876); *Fish. India* II, p. 620 (1878).
[3] Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 296 (1910).

mention of the lateral line in which, as explained above, the specific character is to be found.

Quite a number of specimens have recently been brought back from several places in the Kashmir Valley by the members of the Zoological Survey of India.

Nemachilus yasinensi Alcock.

1898. *Nemachilus yasinensis*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 38, pl. ii, figs. 2, 2*a*.

This species has hitherto been known from a single male specimen procured by Col. Alcock in the Yasin River. The specimen is now preserved in our collection. A large number of specimens have recently been obtained from a small stream flowing into the Sind River, a tributary of the Jhelum River. Among these there are three female specimens which differ considerably from the males. The following are some of the chief points of difference :—

Male.	*Female.*
The dorsal fin commences midway between the tip of the snout and the base of the caudal fin.	The dorsal fin commences somewhat nearer to the base of the caudal than to the tip of the snout.
The snout is slightly longer than the postorbital part of the head.	The snout is shorter than the postorbital part of head.
The lateral line is continued to the base of the caudal fin.	The lateral line ends in front of the base of the ventral fins.
The caudal fin is forked.	The caudal fin is either rounded or truncate.

Besides these the female specimens possess short paired fins, small eyes and a deep caudal peduncle as compared with the males. The males possess well-marked secondary sexual characters such as are described towards the end of this paper.

The eggs are small.

The species is now known from the head-waters of the Indus and Jhelum Rivers.

Nemachilus lhasae Regan

(Text-figs. 3*a*–*c*.)

1905. *Nemachilus lhasae*, Regan, *Ann. Mag. Nat. Hist.* (7) XV, p. 301.
1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.*, II, p. 341.
1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70
1920. *Nemachilus lhasae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 179.

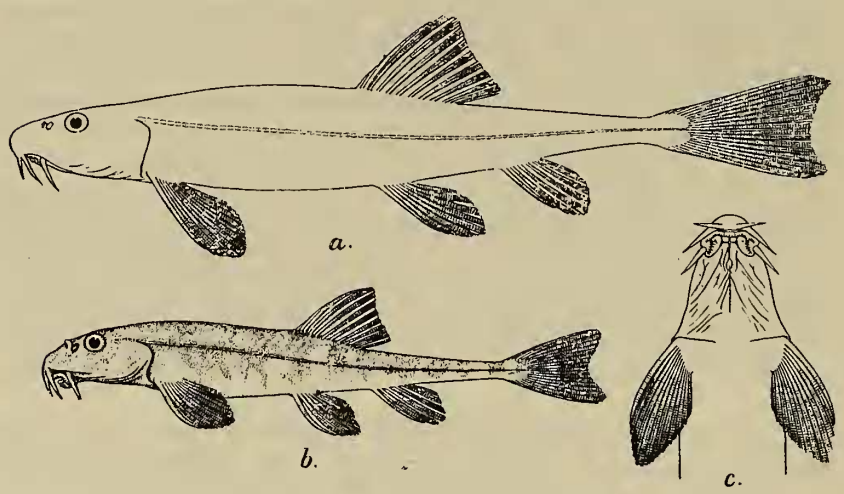
There are several young and half-grown specimens of this species before me, which have been referred to *Nemachilus stoliczkae* by Lloyd. They were collected by Capt. Kennedy and Capt. Stewart in Rhamtso, Nyang-chu, Langma-thang-chu, Phari and to the S.W. of Dochen, all in Eastern Tibet. My specimens agree with Regan's description of the species. The young individuals, however, possess black blotches along the lateral line besides short cross-bars on the back.

The species exhibits well-marked sexual dimorphism.

Nemachilus kashmirensis, sp. nov.

1876. *Nemachilus rupicola*, Day, *Proc. Zool. Soc. London*, p. 799.
1878. *Nemachilus rupicola*, Day, *Sci. Res. 2nd Yarkand Mission-Ichthyol.*, p. 17.

To this new species I assign several specimens recently collected in Verinag, Kukarnag and in a small stream flowing from the Kashmir waterworks reservoir to the trout farm at Harwan. The species is characterized by an emarginate caudal fin and by the presence of broad, black bands across the back. Probably these characters led Day to refer some of his Kashmir examples to *Nemachilus rupicola* (McClell.)[1] I have recently visited the



Text-fig. 3.—*Nemachilus lhasae*, Regan.

a. Lateral view of adult specimen.
b. Same of young specimen.
c. Under surface of head and chest of adult specimen.

Simla Hills and have obtained some specimens of *N. rupicola*, which differ from *N. kashmirensis* in the following points :—

N. kashmirensis.	*N. rupicola.*
The ventrals extend beyond the anal opening and almost reach to the base of the anal fin.	The ventrals do not reach the anal opening and are separated from the anal fin by a considerable distance.
The pectorals are shorter than the head.	The pectorals are longer than the head.
There are no definite black bands on the sides of the body.	There are several black bands on the sides of the body.
The body is absolutely devoid of a scaly covering.	There are minute scales covering at least the posterior three-fourths of the body.

I propose to give a detailed description with figures of this species in my paper on the Indian species of the genus to be published in this journal at some future date.

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[1] McClelland, *Journ. As. Soc. Bengal* VII, p. 948, pl. 55, fig. 3.

Nemachilus tenuis Day.

1876. *Nemachilus tenuis*, Day, *Proc. Zool. Soc. London*, p. 796.
1878. *Nemachilus tenuis*, Day, *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 15, pl. v, fig. 4.
1898. *Nemachilus tenuis*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 14.
1906. *Nemachilus stenurus*, editorial note to Regan, *Journ. As. Soc. Bengal*, II, p. 8.
1920. *Nemachilus stoliczkae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 178.

The specimens from which Day drew up his description of *Nemachilus tenuis*, came from two sources, from "Aktash, where the waters of the Ak-su Pass to the Oxus" and from "Yaukihissar, where the rivers go to the Yarkand River." Day's specimens from the latter locality are not to be found in our collection, though there are several specimens of other species of the genus from the same place. The record, therefore, requires confirmation as I think it improbable that the species really extends to the Tarim river-system. Several specimens from the Great Pamir, whence the waters pass to the Oxus system, were correctly referred to this species by Alcock.

Quite recently Annandale and I (*op. cit.*) identified the Seistan examples as *N. stoliczkae*, but I now believe that they represent *N. tenuis*. The Seistan specimens were collected in the Helmand River which may once have formed a part of the once-extensive Oxus system. Regan (*op. cit.*) referred these specimens to *N. stenurus* on account of their long and narrow caudal peduncle, but this is also a character of *N. tenuis*. The two species differ in the following points:—

N. stenurus Herz.	*N. tenuis* Day.
The commencement of the dorsal fin is nearer to the tip of the snout than to the base of the caudal fin.	The commencement of dorsal fin is either equidistant from the base of the caudal fin and the tip of the snout or it is slightly nearer to the former than to the latter.
The lower lip is continuous and entire.	The lower lip is widely interrupted in the middle and is greatly pliated.

N. stenurus was described from Dy-tsclu, the sources of the Yang-tse-kiang River; while *N. tenuis* is known from the Oxus system.

Vinciguerra[1] on the authority of Regan referred his examples from Skardu in the Indus System to *N. stenurus* for he writes, "nel riferire questi individui al *N. stenurus* sono confortato dall' avviso di Tate Regan, al quale li ho comunicati." The specimens require re-examination.

It is evident from the above discussion that the character of a long and narrow caudal peduncle is shared by a number of species. Such species are *N. stenurus* from the sources of the Yang-tse-kiang, *N. tenuis* from the Oxus system and *N. lhasae*

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[1] Vinciguera, *Ann. Mus. Stor. Nat. Genova* XLVII, p. 148 (1916).

from Eastern Tibet. The Skardu specimens probably represent another form in the same series.

Nemachilus ladacensis Günther.

1868. *Nemachilus ladacensis*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 356.

The Indian Museum possesses only one specimen of this species six and a half inches in length, from Kashmir; it agrees closely with Günther's description but had been referred to *N. stoliczkae* by Day. Day's[1] *N. ladacensis* differs from Günther's account in several respects and probably represents a different species. The descriptions differ in the following points:—

N. ladacensis Günther.	*N. ladacensis* Day.
"The origin of the dorsal fin is nearer to end of snout than to the root of the caudal."	"Dorsal commences midway between the front edge of the eye and the base of the caudal fin."
"The free portion of tail is very low, its depth being nearly one fourth of its length."	"Free portion of the tail twice as high as long at its base."
The caudal fin is rounded?	The caudal fin is emarginate.

The proportions are also different in the two species.

Unfortunately the specimen from which Day drew up his description and which he "deposited in the Indian Museum" is not now to be found.

Day's specimen was said to have been collected by von Schlagintweit at Gnari Khorsum, Tibet. *N. ladacensis* is known from Ladak and Kashmir.

Nemachilus stoliczkae (Steind.).

1866. *Cobitis stoliczkae*, Steindachner, *Verh. Zool-bot. Ges. Wien*, p. 793, pl. xiv, fig. 2.

1868. *Nemachilus stoliczkae*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 360.

A very wide interpretation has been given to this species by Day,[2] Herzenstein,[3] Günther,[4] and several other ichthyologists. I have examined a large number of specimens in our collection from Lukong stream, Chagra, Yarkand, Sirikol and Aktash which were referred to this species by Day but find that several distinct forms are represented among them. There are only six specimens which I can definitely refer to this species, one from Rupshu, the type-locality, three from Lukong Stream, one from Chagra and one from Kashmir. The waters from these places pass to the Indus River.

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[1] Day, *Proc. Zool. Soc. London*, p. 797 (1876); *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 15, pl. iv, fig. 4.

[2] Day, *Proc. Zool. Soc. London*, p. 795 (1876); *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 14, pl. v, fig. 2 (1878).

[3] Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 14 (1888).

[4] Günther, in Pratt's "*Snows of Tibet*", p. 249 (1892).

Herzenstein (*op. cit.*) has recognised several varieties of this species, most of which so far as I can judge from the figures represent different species. My specimens agree with the typical form, of which I have examined one specimen from Rupshu.

Vinciguerra[1] has recorded the species from Skardu, but it appears from his description that he has grouped several distinct forms under one name. In identifying his specimens as *N. stoliczkae* he has followed Day and Herzenstein for he observes that, "questa determinazione é basata non tanto sulla descrizione e figura originale, quanto su quelle di Day, di Günther e specialmente di Herzenstein."

Lloyd[2] referred some specimens from Eastern Tibet to this species. I have been able to recognize at least three different forms among the material he examined, two of them belonging to the genus *Nemachilus*, viz. *N. lhasae* Regan and *N. tibetanus* Regan,[3] while the third belongs to the genus *Diplophysa* and is described here as new.

Day[4] in his later works regarded *Nemachilus griffithii*, Günther,[5] as synonymous with this species. I have not examined any specimen of Günther's species, but it appears from the description that the two are different. In *N. griffithii* "the origin of the dorsal fin is midway between the root of the caudal and the end of the snout," while in *N. stoliczkae* "the origin of the dorsal fin is conspicuously nearer to the root of the caudal than to the end of the snout."

Nemachilus tenuicauda (Steind.).

1866. *Cobitis tenuicauda*, Steindachner, *Verh. Zool.-bot. Ges. Wien* XVI, p. 792, pl. 17, fig. 3.
1868. *Nemachilus tenuicauda*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 357.

This species closely resembles *N. stoliczkae*, from which it is distinguished by its elongate and narrow caudal peduncle and by its colouration.

Nemachilus tenuicauda is represented in our collection by two specimens from Leh.

Nemachilus marmoratus (Heckel).

1838. *Cobitis marmorata*, Heckel, *Fish. Kaschm.*, p. 76, pl. xii, figs. 1 and 2.
1844. *Cobitis marmorata*, Heckel, in Hügel's *Kaschmir* IV, p. 380, fig.

This is apparently a rare species and is represented in our collection by a few specimens recently obtained in Kashmir. The specimens were obtained from Kukarnag Spring and from ponds on the road between Martand and Ichabal.

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[1] Vinciguerra, *Ann. Mus. Stor. Nat. Genova* XLVII, p. 146 (1916).
[2] Lloyd, *Rec. Ind. Mus.* II, p. 341 (1908).
[3] Regan, *Ann. Mag. Nat. Hist.* (7) XV, pp. 187 and 301 (1905)
[4] Day, *Fish. India* II, p. 620 (1878).
[5] Günther, *Cat. Brit. Mus. Fish.* VII, p. 360 (1868).

I am unable to say whether Zugmayer's (*op. cit.*) specimens represent this species or *N. vittatus*, but the latter is undoubtedly more common in the Kashmir lakes.

For the reasons already given under *N. vittatus* I have not included references by Günther and Day under the title of this species.

Nemachilus microps (Steind.).

1866. *Cobitis microps*, Steindachner, *Verh. Zool.-bot. Ges. Wien* XVI, p. 794, pl. 13, fig. 3.
1868. *Nemachilus microps*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 357.

This species is readily distinguished by its small eyes. We have two specimens in our collection from Mecma [1] (Yarkand Mission, Dr. Stoliczka's collection) which agree with Steindachner's description of the species. These specimens had previously been referred to *Nemachilus stoliczkae*. The male possesses well-marked secondary sexual characters below the eyes.

The species was originally described from Leh and in all probability the waters from Mecma pass to the Indus River.

Nemachilus tibetanus Regan.

(Text-figs. 2*a*, 2*b*.)

1905. *Nemachilus tibetanus*, Regan, *Ann. Mag. Nat. Hist.* (7) XV, p. 187.
1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.* II, p. 341.
1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70.

The specimens before me of this species were collected by Capt. Kennedy in Nyang-chu at Kangmar and by Capt. Stewart in Gyang-tse. These had been referred to *Nemachilus stoliczkae* by Lloyd and Stewart. The species differs from *N. lhasae*, which is known from the adjacent region, by the greater depth of its caudal peduncle, by the position of the dorsal fin, whose commencement is situated nearer to the root of the caudal than to the tip of the snout, and by the position of the eye, which is nearer to the tip of the snout than to the posterior margin of the head.

Nemachilus tibetanus exhibits a well-marked sexual dimorphism.

Nemachilus sp.

There are several specimens in our collection from Sirikol, which have been referred to *Nemachilus stoliczkae* by Day with the following remark, "in specimens from Sirikol the snout is rather more pointed." I am unable to refer these specimens to any of the known species of the genus, but on account of their bad state of preservation I do not propose to describe them as a new species.

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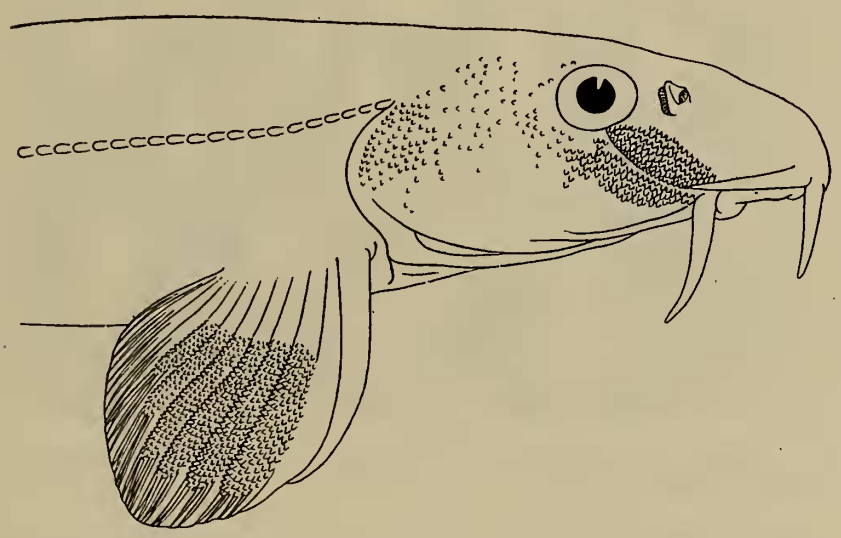
[1] The Yarkand Mission made collections in several places outside Yarkand. I have not been able to determine the exact locality of Mecma, but I suppose waters from this place flow into the Indus river-system.

Among the specimens from this locality two forms are represented, one in which the caudal peduncle is very low and the commencement of the dorsal fin is situated at an equal distance from the tip of the snout and the base of the caudal fin; while in the other the caudal peduncle is fairly deep and the origin of the dorsal fin is distinctly nearer to the base of the caudal than to the tip of the snout. Most of the females, which are about 54 mm. in length, are full of eggs. The snout is long and pointed and the eyes are situated in the middle of the head.

Note on the Secondary Sexual Characters of certain Species of Cobitid Fishes from high Altitudes in Central Asia.

In the Indian species of the genus *Nemachilus* which exhibit sexual dimorphism the male is provided with "a slit-like



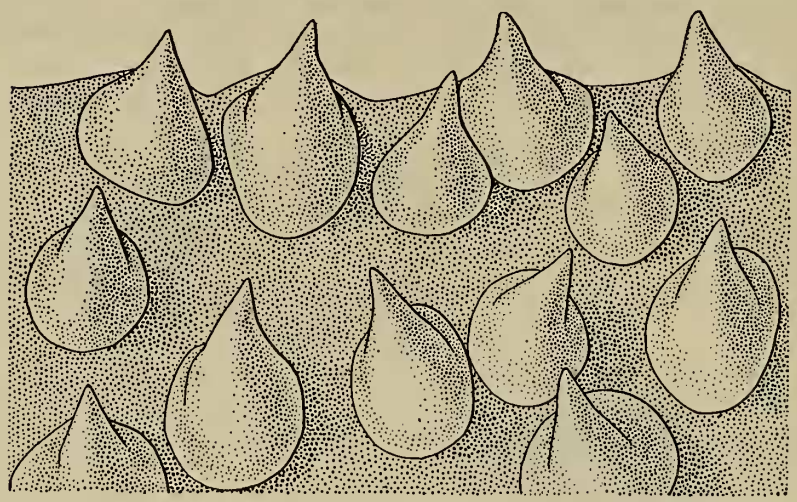
Text-fig. 4.—Lateral view of head and upper surface of pectoral fin in a male specimen of *Nemachilus tibetanus* Regan, showing secondary sexual characters.

deep groove in front of the eye which bends round a small knob-like rounded flap of skin protruding below the anterior one-third of the orbit, the ridge above the groove appearing slightly swollen and cushion-like." The pectoral fins are also modified where "there is a kind of padding and thickening on the upper surface" and "on the padding, minute hooked denticular outgrowths are noticed." These secondary sexual characters were described by Chaudhuri in *Nemachilus mackenziei*[1] and *N. manipurensis*[2] and

[1] Chaudhuri, *Rec. Ind. Mus.* V, p. 183.

[2] Chaudhuri, *Rec. Ind. Mus.* VII, p. 443, pl. xl, figs. 4, 4*a*, 4*b*; pl. xli, figs. 1, 1*a*, 1*b*.

I have noticed similar modifications in mature males of several other Indian species of the genus. In the Central Asiatic forms, however, the secondary characters of the male are more marked and somewhat complicated. Of the thirteen species of the genus *Nemachilus* referred to in this paper, seven show marked sexual dimorphism. The male in these is usually provided with a raised tuberculate area below the nares, separated ventrally by a groove from the adjacent parts of the skin. The area is almost rectangular, commencing at the corner of the lips and extending posteriorly below the anterior third of the orbit. In certain species such as *N. tenuis*, *N. yasinensis* and *N. tibetanus* (fig. 4), there is another tuberculate area immediately behind the first one. Sometimes the tubercles are irregularly scattered on the operculum and the sides of the head behind the eyes. In all species that exhibit



Text-fig. 5.—Tubercles covering secondary sexual pads of male of *N. tibetanus* (highly magnified).

sexual dimorphism, the pectoral fin-rays are provided with thickened tuberculate pads on their dorsal aspect. These tubercles on the fin-rays are not to be confused with encysted glochidia, which are sometimes found in this position, though they resemble them closely. A few scattered tubercles are sometimes found on the under surface of the pectoral fin-rays.

In both the species of the genus *Diplophysa* in our collection, the male is modified on exactly the same lines as has already been described for the genus *Nemachilus*.

The structure of the tuberculate areas is somewhat interesting. Each of the tubercles is provided with a short, stout spine-like outgrowth (fig. 5) which is sharp and slightly curved towards the end. The spine rests on a broad cushion-like rounded base.

Recently I have collected an interesting specimen of *Nemachilus* from the Simla Hills. It possesses a groove and a small

knob-like rounded flap of skin below the eye, but on dissection was found to be full of eggs. There is no padding on the dorsal aspect of the pectoral fin-rays and even the sexual character below the eye is not so well marked. I have examined a large number of specimens of the species to which I think this example probably belongs, *N. rupicola* (McClelland), and have not been able to find any other specimen with secondary sexual characters.